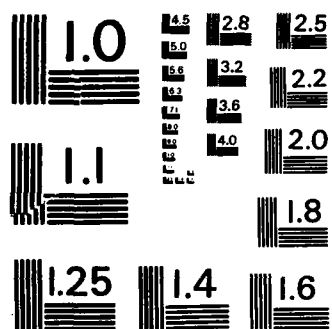AD-A166 062   SEQUENTIAL AND PARALLEL MATRIX COMPUTATIONS(U) NORTHERN   1/1
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INTERIM REPORT ON
''SEQUENTIAL AND PARALLEL MATRIX COMPUTATIONS''

by

Biswa Nath Datta
Northern Illinois University
DeKalb, IL 60115

Presented to the Air Force Office of Scientific Research.

The major objectives of this project are to develop computational

algorithms, both sequential and parallel, for several important linear algebra

problems that arise in the design and analysis of linear control systems

governed by the systems of ordinary differential equations. Then include

(i) controllability problems, (ii) stability and inertia problems, (iii) pole

assignment problems, (iv) matrix equations problems, (v) relative primeness

of polynomials and matrices and the Cauchy-index problems of rational

functions etc. Besides, a part of the project is devoted to the

theoretical study of the parallel arithmetic complexity of these problems,

that is, how fast these problems can be solved in parallel assuming that

sufficiently many processors are available.

Though some numerically viable sequential algorithms have been designed

for some of these problems in recent years, parallel algorithms and

algorithms for large scale problems are virtually non-existent.

I am very pleased to report that we have taken a "LEAD" in this area.

Since my''INTERIM REPORT'' last October, the following additional

accomplishments have been made:

(A) Linear-time steps algorithms requiring only $O(n)$ processors for

implementations have been developed for controllability, observability,

stability, inertia and Cauchy index problems for polynomials. These are

sharp improvements over our $O(n \log_2 n)$ steps $- O(n^2)$ processors

algorithms reported last year. Especially, savings in number of processors is significant. The results have been presented at the SIAM Conference on Parallel processing for Scientific Computations, Norfolk, Virgina, November 1985. The paper based on these results is presently being written up.

(B) Fast sequential and parallel algorithms have been developed for (i) determining relative primeness and the number of common eigenvalues between two given matrices and (ii) finding the inertia and stability of a non-hermitian matrix. Sequentially, these algorithms are more efficient than the existing procedures and in parallel, they can be implemented in almost linear time steps using at most $O(n^2)$ processors. A paper based on these results has just appeared in a special issue of CONTEMPORARY MATHEMATICS (Volume 47) on "Linear Algebra and its Role in Systems Theory" published by the American Math Society.

(C) Jointly with A. Sameh of University of Illinois, a parallel algorithm for the single-input pole assignment, seemed to be suitable for a shared memory multiprocessor like Cray X - MP/48, has been developed. The algorithm is presently being implemented on "Alltant" system at University of Illinois.

(D) It has been shown that the parallel arithmetic complexity of the QR factorization of a matrix A is upper bound by $O(\log_2^2 n)$ steps. As an application of this result, a parallel algorithm requiring only $O(\log_2 n)$ steps and $O(n)$ processors for computing the eigenvalues of a symmetric tridiagonal matrix has been developed. The algorithm has been implemented on HEP at Argonne National Laboratory in an M.Sc. thesis at Northern Illinois University by Ava Chun and, the results were compared with parallel Q-R algorithm of Sameh and Kuck and the method of multisectioning. The

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results will soon appear in a paper in INTERNATIONAL JOURNAL OF COMPUTER
MATHEMATICS.

(E) A new result on the existence, uniqueness and nonsingualirity of
solutions of a *special type of Sylvester's equation*:   AX + XB = C, has been
obtained. As applications, direct methods have been developed for
constructing symmetrizers, computing the characteristic polynomial of a
matrix and finding the numbers of common eigenvalues between two matrices.
The results were presented at the SIAM Conference on Applied Linear Algera,
Raleigh, NC, 1985, and the paper has been accepted for publication in
LINEAR ALGEBRA AND ITS APPLICATIONS.

(F) Two new algorithsm have been developed to compute the
characteristic polynomial of a Hessenberg matrix, they are more efficient
than the existing ones: one by the P.I. and the other due to Wilkinson.
Also it has been shown that the parallel arithmetic complexity of this
problem is upper bounded by $O(\log_2^2 n)$ parallel steps. The paper has
appeared in J. INDUSTRIAL MATH. SOCIETY.

(G) A new efficient ($O(n \log_2 n)$ steps) parallel algorithm *has been*
developed to compute the zeros of a polynomial. The paper is being written
up.

(H) An efficient highly parallel algorithm has been designed tosolve
the matrix equation problem: AX + XB = C, in the case A is a symmetric
matrix. Attempt is being made to extend the algorithm to the nonsymmetric
case. The preliminary results were presented at the SIAM Conference on
Applied Linear Algelbra, Raleigh, NC, April 1985.

(I) By means of constructive procedures it has been shown that most of
the control problems under discussion can be solved in as fast as $O(\log_2^2 n)$
parallel steps using sufficiently many processors. These results are

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of theoretical interests only at present. The results will appear in the paper "On Parallel Arithmetic Complexities of Some Linear Algebra Problems in Control Theory".

A brief overview of these results were presented by the principal investigator in an INVITED session on "Linear Algebra and Systems Theory II" at the International Symposium on Mathematical Theory of Networks and Systems, Stockholm, Sweden, June 1985. An INVITED paper entitled 'Theroetiical and Computational Aspects of Some Linear Algebra Problems in Control Theory" based on this talk will soon appear in the PROCEEDINGS OF THE CONFERENCE published by North-Holland: C. Byrnes and A. Lindquist editors. An one-hour KEY-NOTE address was also given by the principal investigator at the International Conference on Linear Algebra and its Application in Coimbra, Portugal, March, 1985, based on some of these results. Besides these conference talks, several INVITED colloquium talks have been delivered by the principal investigator in and outside the Untied States. They include colloquium talks at: 1) Yale University, New Haven, Connecticut, 2) University of Illinois at Urbana-Champaign, 3) Kent State University, Kent, Ohio, 4) Indian Institute of Technology, Bombay, India, 5) Indian Statistical Institute, Calcutta, India and 6) Tata Institute of Fundamental Research, Bombay, India, etc.

The principal investigator will also present a half-hour talk at the IEEE CDC Conference in Florida, December 1985 and has accepted invitations to give INVITED talks at the (i) International Conference on Linear Algebra and Analysis, Czechoslovakia, March, 1986, and (ii) American Control Conference, Seattle, Washington, June 1986.

In designing the parallel algorithms reported in this paper, a special attention has been given to the use of the existing efficient parallel

algorithms for various types of matrix computations. As a result, these algorithms have potentials for immediate implementations on some of the existing and presently-built parallel machines. Our present attention is being focused on implementating some of the algorithms on DAP, Alliant System at University of Illinois, Urbana-Champaign, and other available machines, improve and redesign the already-developed algorithms for the existing machines and develop algorithms for Large-Scale Control problems. In the area of Large-Scale computations with control problem, a lot remains to be done in yearrs ahead - the field is wide-open.

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FIELD	GROUP	SUB. GR.	Linear-time step algorithms, matrix computations, parallel algorithms

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Linear-time step algorithms requiring only $O(n)$ processors for implementation have been developed for controllability, observability, stability, inertia and Cauchy index problems for polynomials. These results were presented at the SIAM Conference of Parallel Processing for Scientific Computations in November 1985. Also, a paper on fast sequential and parallel algorithms for determining relative promeness and the number of common eigenvalues between two given matrices and finding the inertia and stability of a nonhermitian matrix has appeared in a special issue of Contemporary Mathematics on "Linear algebra and its role in systems theory".

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